Crooked Lake
Aquatic Vegetation Management Plan
2007 Update-Draft

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Executive Summary

Aquatic Control was contracted by the Crooked Lake Association to complete aquatic vegetation sampling in order to update their lakewide, long-term integrated aquatic vegetation management plan which was originally completed in 2007. Funding for the update of this plan was obtained from the Crooked Lake Association and the Indiana Department of Natural Resources-Division of Fish and Wildlife as part of the Lake and River Enhancement program (LARE). The update will serve as a tool to track changes in the vegetation community, to adjust the action plan as needed, and to maintain eligibility for additional LARE funds. Items covered include the 2007 sampling results, a review of the 2007 vegetation controls, and updates to the budget and action plans.

Aquatic vegetation is an important component of lakes in Indiana; however, as a result of many factors this vegetation can develop to a nuisance level. Nuisance aquatic vegetation, as used in this paper, is described as plant growth that negatively impacts the present uses of the lake including fishing, boating, swimming, aesthetic, and lakefront property values. The primary nuisance species within Crooked Lake is the exotic plant Eurasian watermilfoil (*Myriophyllum spicatum*), hereafter called milfoil. Curlyleaf pondweed *(Potamogeton crispus*) is another exotic species abundant in Crooked Lake. The original plan recommended a pre-treatment invasive species mapping survey followed by treatment of milfoil with a combination of fluridone in the third basin and 2,4-D spot treatments in the second basin followed by a summer Tier II survey. Other recommendations in the original plan included the following; posting of signs at all ramps encouraging boaters to thoroughly clean their boats and trailers of all plant material, eco-zones be explored for areas on the first and second basins, purple loosestrife be physically removed on individual property, limited treatment on native vegetation in high-use areas, act upon recommendations in the watershed study, and cooperation with other lakes in the watershed in reducing invasive species and improving water quality.

As planned, invasive species sampling was completed prior to treatment on May 9, 2007. This sampling indicated the presence of approximately 62.0 acres of Eurasian watermilfiol in the first and second basins. Milfoil was present in nearly the entire third basin (approximately 184 acres). Curlyleaf pondweed was documented in 23.6 acres of the first and second basins and nearly the entire third basin. On May 14 an initial dose of fluridone was applied to third basin with a goal of maintaining above 3 ppb fluridone for 90 days. The third basin treatment required several bump applications, but 3 ppb was maintained for the required time. On May 22, spot treatments were completed on the first and second basin with 2,4-D granular herbicide for control of milfoil. A summer Tier II survey was completed on August 8, 2007. A total of 12 native submersed species was collected. Chara (*Chara spp.*) was the most abundant species followed by slender naiad (*Najas flexilus*). Milfoil was significantly reduced when compared to 2006 survey results.

In 2008, it is unlikely that milfoil will be abundant in the third basin, however, it will be present in the first and second basins but likely at a lower abundance. It is important that these remaining beds of milfoil be treated with systemic herbicides next season in order

to further reduce its abundance and reduce the chances of reinfestation in the third basin. The third basin should also be thoroughly sampled in case any milfoil survived or was introduced. It is estimated that up to 50 acres of milfoil may require treatment next season. In addition, curlyleaf pondweed will likely continue to be a problem. Up to 155 acres of curlyleaf pondweed may be present in Crooked Lake next season. This estimate is based upon the findings from the 2007 invasive plant mapping survey. Curlyleaf pondweed will likely be most abundant in the third basin (133 acres). Priority should be placed on controlling the milfoil, but the grant request should include the curlyleaf pondweed treatment.

It is recommended that the Crooked Lake Association request $17,500 for treatment of up to 50 acres of milfoil with 2,4-D herbicide, $38,750 for early season treatment of up to 155 acres of curlyleaf pondweed, $5,000 for basic plant sampling and plan update, and an additional $5,000 for curlyleaf turion sampling and early spring Tier II survey (only to be completed if curlyleaf treatment is completed).

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1.0 INTRODUCTION

This report was created in order to update the Crooked Lake Aquatic Vegetation Management Plan. The update will serve as a tool to track changes in the vegetation community, to adjust the action plan as needed, and to maintain eligibility for additional LARE funds. Items covered include the 2007 sampling results, a review of the 2007 vegetation controls, and updates to the budget and action plans. The plan update was funded by the Indiana Department of Natural Resources Lake and River Enhancement Program (LARE) and the Crooked Lake Association (CLA).

2.0 2007 SAMPLING RESULTS

Two plant surveys were completed in 2007. An invasive species mapping survey was completed on May 9. The invasive mapping survey allowed for the determination of potential control areas and the documentation of any changes in the abundance of invasive species. A Tier II survey was completed on August 8. This survey was completed in order to document success or failure of the control techniques, document changes in the native plant community, and aid in the planning for future actions.

2.1 Spring Invasive Mapping Results

On May 9, 2007, an invasive mapping survey was completed on Crooked Lake. A Secchi disc reading was taken and found to be 15.0 feet. The water temperature was 65.4F at the surface and 58.2F at the bottom. Dissolved oxygen was 10.1 mg/L at the surface and 9.8 mg/L at the bottom. Sampling indicated the presence of approximately 62.0 acres of Eurasian watermilfiol in the first and second basins (Figure 1). Milfoil was present in nearly the entire third basin, but more dense in the northern half of the basin (Figure 2). Curlyleaf pondweed was documented in 23.6 acres of the first and second basins (Figure 3). Curlyleaf was mixed in with the milfoil throughout the third basin and most abundant near the middle of the basin (Figure 2).

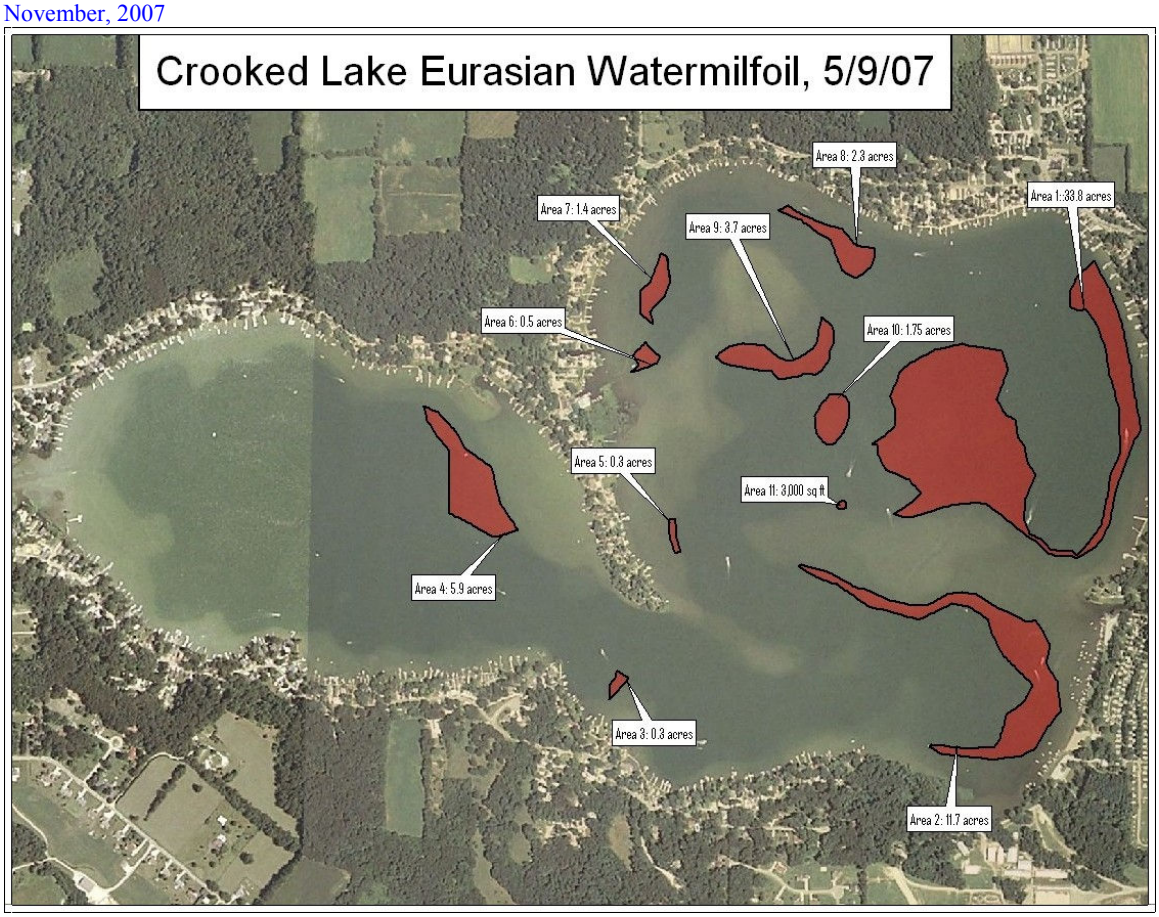

Figure 1. Eurasian watermilfoil beds, Crooked Lake, first and second basin, May 9, 2007

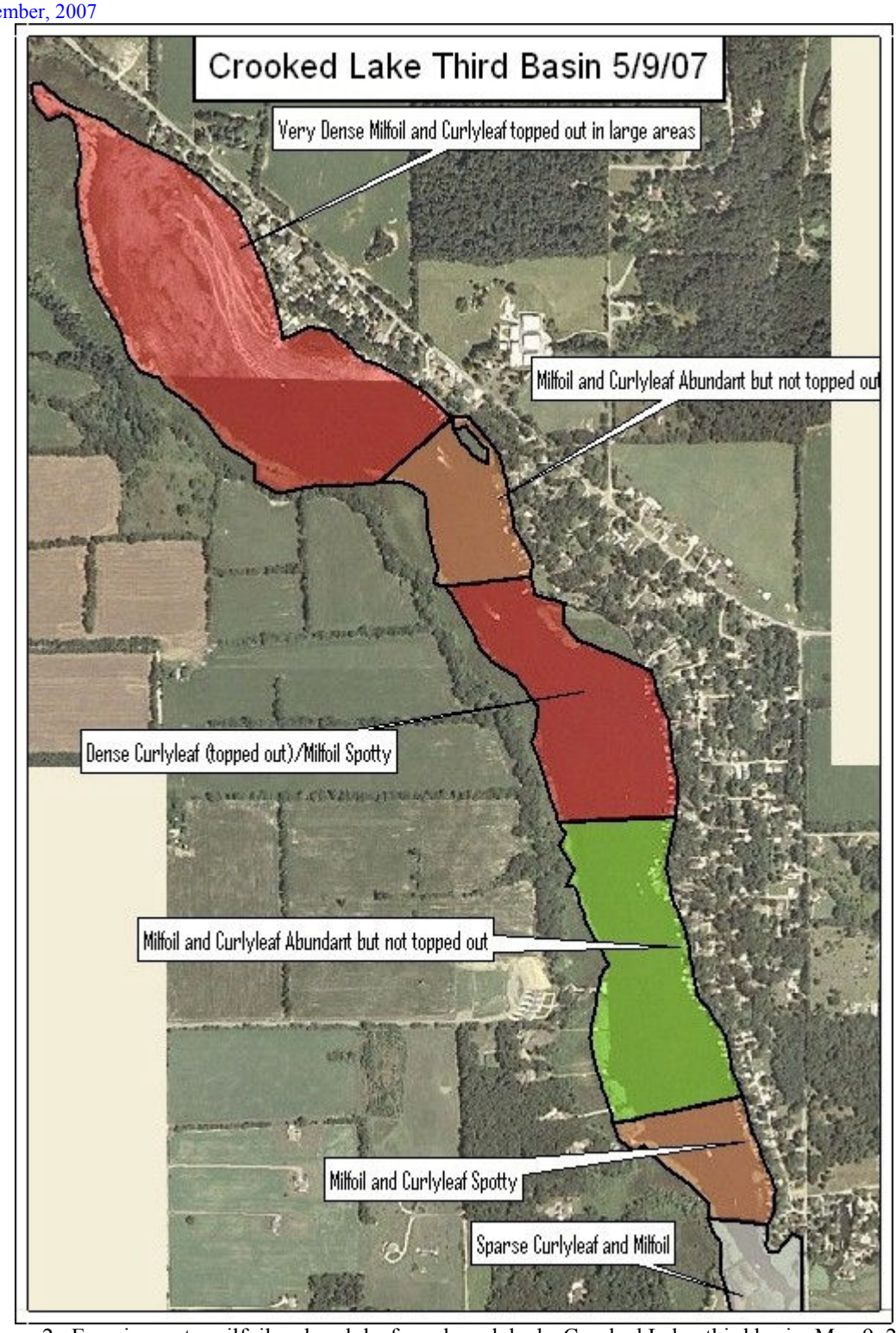

Figure 2. Eurasian watermilfoil and curlyleaf pondweed beds, Crooked Lake, third basin, May 9, 2007

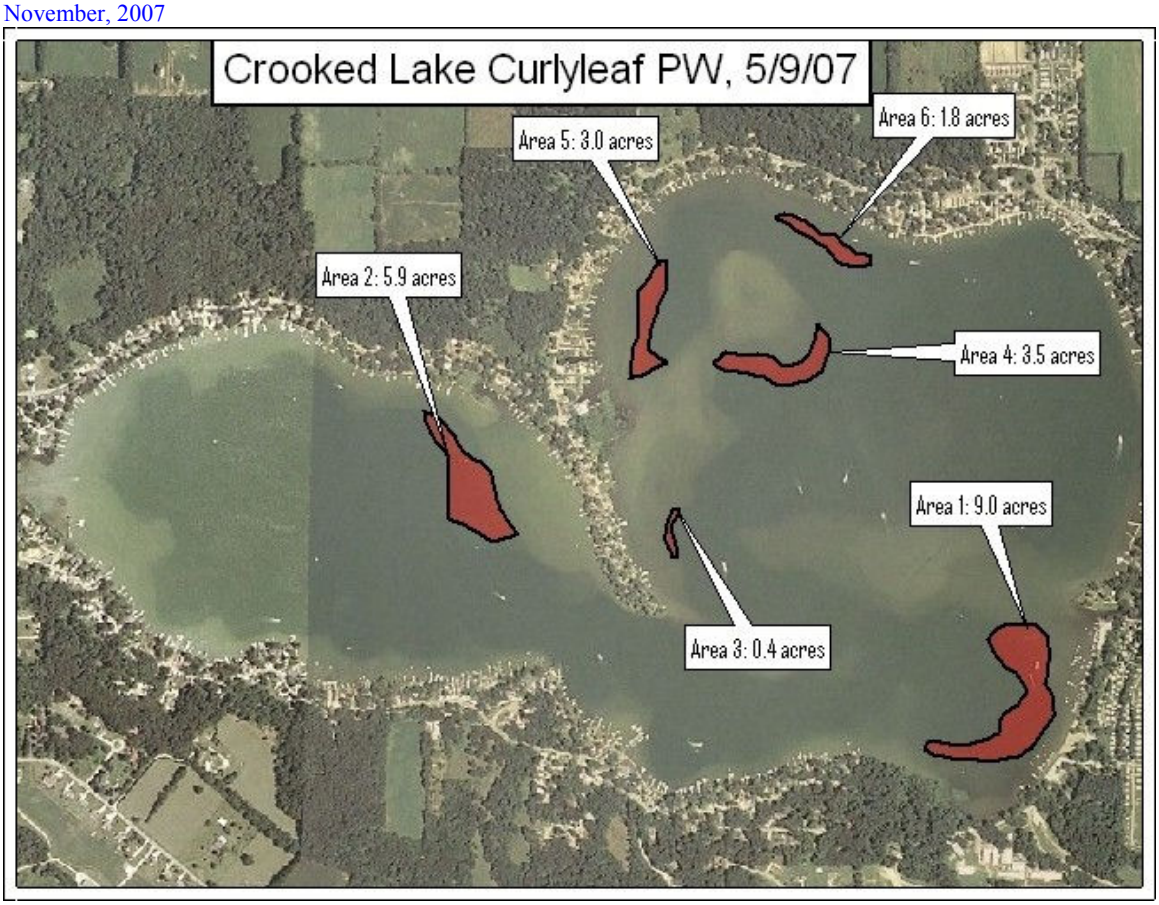

Figure 3. Curlyleaf pondweed beds, Crooked Lake, first and second basin, May 9, 2007

2.2 Summer Tier II Survey

On August 14, 2007 a Tier II survey was completed on Crooked Lake. A Secchi disk reading was taken prior to sampling and was found to be 6.0 feet. Plants were present to a maximum depth of 20.0 feet. The same 100 sites that were sampled in 2006 were again sampled in 2007. Plants were present at 64 of the sample sites and native plants were present at 63 of the sites. A total of 14 species were collected of which 12 of the species were native. The mean number of species collected per site was 1.50 and the mean number of native species collected was 1.34. The species diversity index was 0.87 and the native species diversity index was 0.84 (Table 1).

Table 1. Occurrence and abundance of submersed aquatic plants in Crooked Lake, August 14, 2007.

Occurrence and abundance of submersed aquatic plants in Crooked Lake

County:	Stuben	Sites with plants:	64	Mean species/site:	1.50
Date:	8/14/2007	Sites with native plants:	63	Standard error (ms/s):	0.1501
Secchi (ft):	6	Number of species:	14	Mean native species/site:	1.34
Maximum plant depth (ft):	20	Number of native species:	12	Standard error (mns/s):	0.1358
Trophic status	Mesotrophic	Maximum species/site:	7	Species diversity:	0.87
Total sites:	100			Native species diversity:	0.84

All depths (0 to 25 ft)	Frequency of	Rake score frequency per species				Plant Dominance
Species	Occurrence	0	1	3	5	
Chara	33.0	67.0	17.0	6.0	10.0	9.4
slender naiad	29.0	71.0	13.0	6.0	10.0	11.4
Eurasian watermilfoil	16.0	84.0	9.0	3.0	4.0	4.4
common coontail	14.0	86.0	8.0	1.0	5.0	5.6
curlyleaf pondweed	10.0	90.0	5.0	2.0	3.0	4.0
sago pondweed	10.0	90.0	4.0	0.0	6.0	4.4
American elodea	9.0	91.0	0.0	2.0	5.0	3.0
large leaf pondweed	9.0	91.0	4.0	1.0	4.0	3.8
Richardson's pondweed	8.0	92.0	2.0	1.0	5.0	4.0
flatstemmed pondweed	5.0	95.0	1.0	2.0	2.0	1.4
eel grass	3.0	97.0	1.0	1.0	1.0	0.6
southern naiad	2.0	98.0	2.0	0.0	0.0	0.4
common bladderwort	1.0	99.0	0.0	0.0	1.0	0.6
leafy pondweed	1.0	99.0	1.0	0.0	0.0	0.2

All depths (0 to 5 ft)	Frequency of	Rake score frequency per species				Plant Dominance
Species	Occurrence	0	1	3	5	
Chara	40.5	59.5	27.0	2.7	10.8	11.4
large leaf pondweed	16.2	83.8	8.1	0.0	8.1	5.4
slender naiad	16.2	83.8	5.4	2.7	8.1	6.5
common coontail	10.8	89.2	2.7	0.0	8.1	6.5
curlyleaf pondweed	10.8	89.2	5.4	0.0	5.4	3.2
Eurasian watermilfoil	10.8	89.2	8.1	0.0	2.7	2.2
Richardson's pondweed	10.8	89.2	0.0	2.7	8.1	7.6
American elodea	8.1	91.9	0.0	0.0	8.1	3.8
flatstemmed pondweed	8.1	91.9	0.0	2.7	5.4	2.7
sago pondweed	8.1	91.9	2.7	0.0	5.4	2.7
common bladderwort	2.7	97.3	0.0	0.0	2.7	1.6
eel grass	2.7	97.3	2.7	0.0	0.0	0.5

All depths (5 to 10 ft)	Frequency of	Rake score frequency per species				Plant Dominance
Species	Occurrence	0	1	3	5	
slender naiad	41.9	58.1	16.3	9.3	16.3	18.6
Chara	39.5	60.5	14.0	11.6	14.0	11.6
Eurasian watermilfoil	23.3	76.7	11.6	4.7	7.0	7.4
curlyleaf pondweed	14.0	86.0	11.6	4.7	2.3	6.5
sago pondweed	14.0	86.0	4.7	0.0	9.3	7.4
common coontail	11.6	88.4	7.0	0.0	4.7	4.2
American elodea	9.3	90.7	2.3	2.3	4.7	1.9
Richardson's pondweed	9.3	90.7	4.7	0.0	4.7	2.8
large leaf pondweed	7.0	93.0	2.3	2.3	2.3	4.2
eel grass	4.7	95.3	0.0	2.3	2.3	0.9
flatstemmed pondweed	2.3	97.7	0.0	2.3	0.0	0.5
leafy pondweed	2.3	97.7	2.3	0.0	0.0	0.5
southern naiad	2.3	97.7	2.3	0.0	0.0	0.5

All depths (10 to 15 ft)	Frequency of	Rake score frequency per species				Plant Dominance
Species	Occurrence	0	1	3	5	
common coontail	80.0	20.0	60.0	20.0	0.0	24.0
Eurasian watermilfoil	40.0	60.0	20.0	20.0	0.0	8.0
slender naiad	40.0	60.0	20.0	20.0	0.0	8.0

All depths (15 to 20 ft)	Frequency of	Rake score frequency per species				Plant Dominance
Species	Occurrence	0	1	3	5	
slender naiad	20.0	80.0	20.0	0.0	0.0	4.0
American elodea	13.3	86.7	6.7	6.7	0.0	5.3
Chara	6.7	93.3	6.7	0.0	0.0	1.3
common coontail	6.7	93.3	6.7	0.0	0.0	1.3
flatstemmed pondweed	6.7	93.3	6.7	0.0	0.0	1.3
sago pondweed	6.7	93.3	6.7	0.0	0.0	1.3
southern naiad	6.7	93.3	6.7	0.0	0.0	1.3

AQUATIC CONTROL

Chara ranked first in frequency of occurrence (33.0%) and second in dominance (9.4). Location and density of Chara is illustrated in Figure 4. Slender naiad was the second most frequently occurring species (29.0%) but ranked first in dominance (Figure 5). Eurasian watermilfoil was collected at 16% of sample sites making it the most frequently occurring exotic species and ranking third in overall frequency (Figure 6). Milfoil frequency was higher than expected, but that was likely due to the inclusion of identifiable milfoil stems in the third basin that were likely not viable. Common coontail (*Ceratophylum demersum*) ranked fourth in frequency (Figure 7), followed by curlyleaf pondweed (Figure 8), sago pondweed (*Potamogeton pectinatus*), American elodea (*Elodea canadensis*), largeleaf pondweed (*Potamogeton amplifoilus*) (Figure 9), richardson's pondweed (*Potamogeton richardsonii*), flatstem pondweed (*Potamogeton zosteriformis*), eel grass (*Valisneria americana*), southern naiad (*Najas guadalupensis*), common bladderwort (*Utricularia vulgaris*), and leafy pondweed (*Potamogeton foliosus*). Flatstem pondweed was the only species collected in the August 2007 survey that was not collected in August, 2006. Variable pondweed (*Potamogeton gramineus*), Illinois pondweed (*Potamogeton illinoensis*), brittle naiad (Najas minor), water stargrass (*Zosterella dubia*), variable watermilfoil (*Myriophyllum heterophylum*), small pondweed (*Potamogeton pusillus*), and western elodea (*Elodea nuttallii*) were collected in August of 2006 but not in August of 2007.

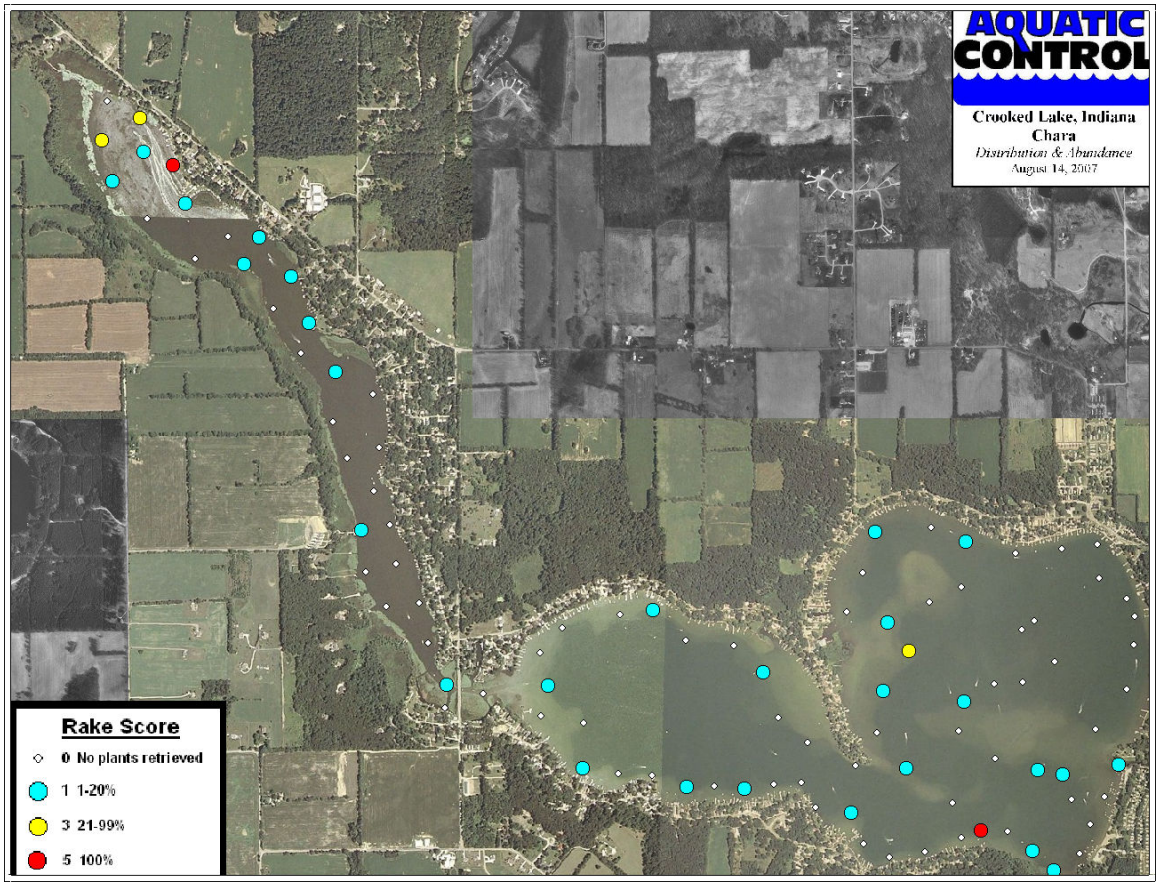

Figure 4. Crooked Lake, Chara distribution and abundance, August 14, 2007.

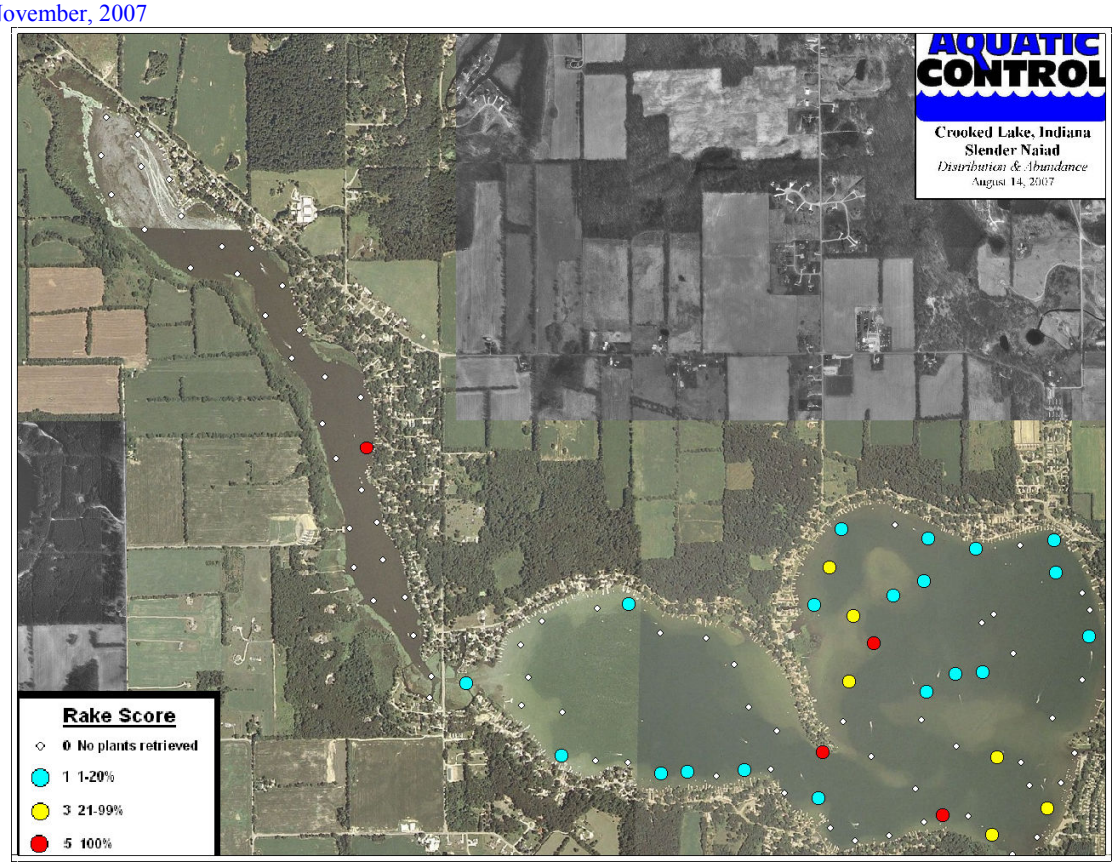

Figure 5. Crooked Lake, slender naiad distribution and abundance, August 14, 2007.

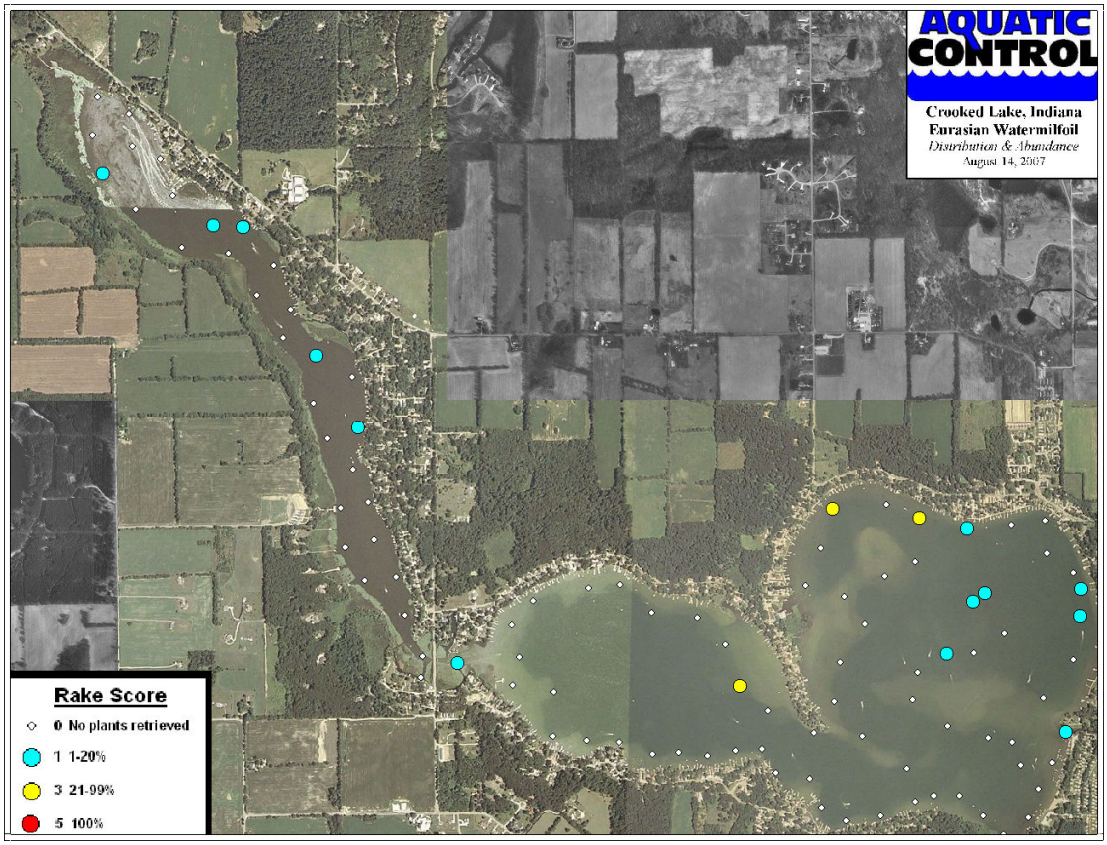

Figure 6. Crooked Lake, Eurasian watermilfoil distribution and abundance, August 14, 2007.

Figure 7. Crooked Lake, common coontail distribution and abundance, August 14, 2007.

Figure 8. Crooked Lake, curlyleaf pondweed distribution and abundance, August 14, 2007.

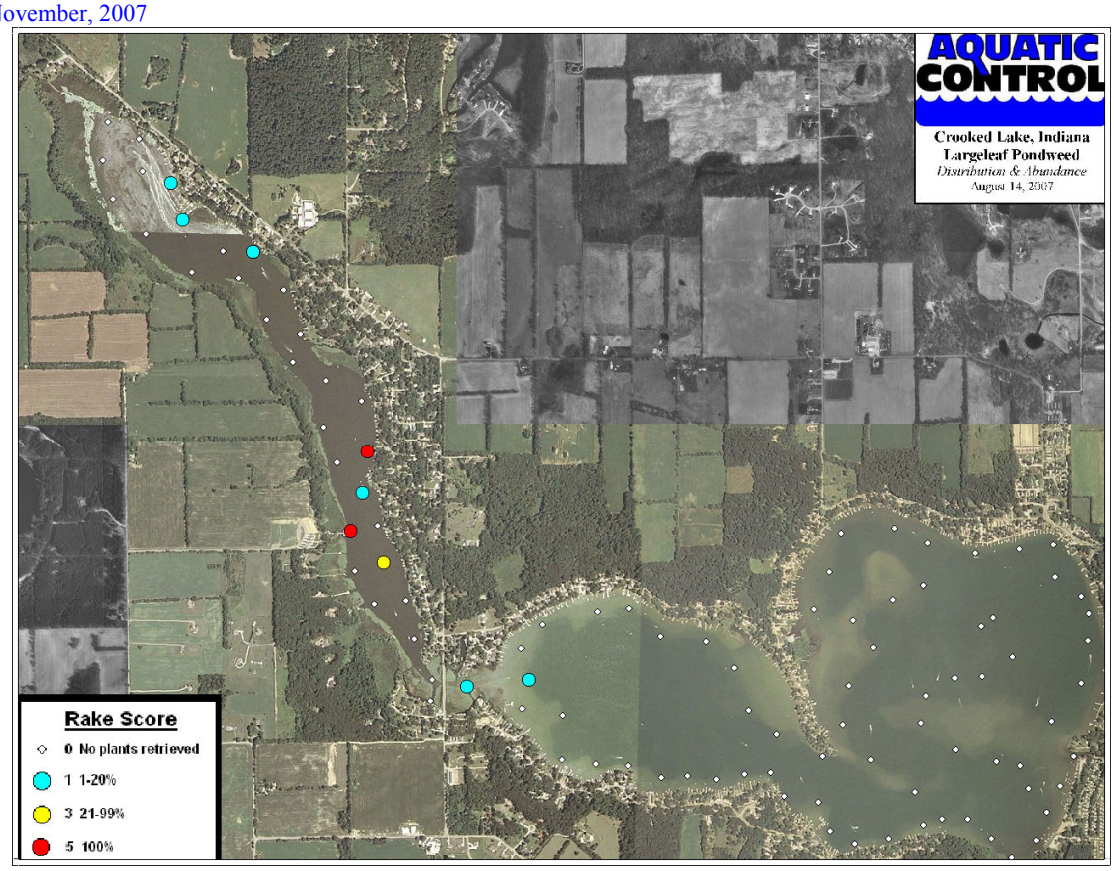

Figure 9. Crooked Lake, largeleaf pondweed distribution and abundance, August 14, 2007.

2.3 Aquatic Vegetation Sampling Discussion

One of the main actions recommended in the 2006 plan was the continued monitoring of vegetation. As previously mentioned, sampling consisted of invasive mapping in the spring followed by a Tier II survey in the summer.

Invasive mapping appeared to be effective at locating the majority of the milfoil problem areas. This conclusion is reached when comparing the summer Tier II milfoil map to the spring milfoil map. The summer survey detected very little milfoil outside of the areas that were mapped in the spring. Spring invasive mapping also allowed for an acreage estimate on curlyleaf pondweed. This mapping provides a good baseline data set in order to monitor the potential spread of this species and to allow for budget estimates for control.

One of the primary goals of the plan is to reduce the negative impacts caused by nuisance invasive species. The primary nuisance species in Crooked Lake is Eurasian watermilfoil. This species exhibited a significant decline this season that can likely be attributed to vegetation controls (Figure 10). Prior to treatment, milfoil and curlyleaf pondweed made navigation in the third basin difficult if not impossible. Navigation was not a serious problem at the time of the summer survey.

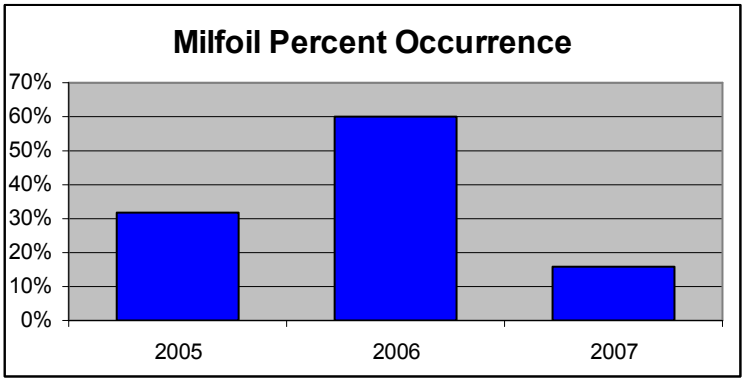

Figure 10. Crooked Lake, Eurasian watermilfoil percent occurrence in the last three summer surveys (2005 Tier II data provided by IDNR).

Curlyleaf pondweed is one of the most common invasive species in Crooked Lake. This species tends to decline by late summer, but has been documented in past summer surveys. There appears to have been an increase in the abundance of this species in 2007 when compared to past surveys (Figure 11). This is somewhat surprising since curlyleaf was not detected in the third basin this season due to the fluridone application. The reason for the increase is not entirely clear, but may be attributed to a change in herbicides. Last season milfoil beds were treated with a contact herbicide that also affects curlyleaf pondweed, while this season these beds were treated with a selective systemic herbicide that has no effect on pondweeds.

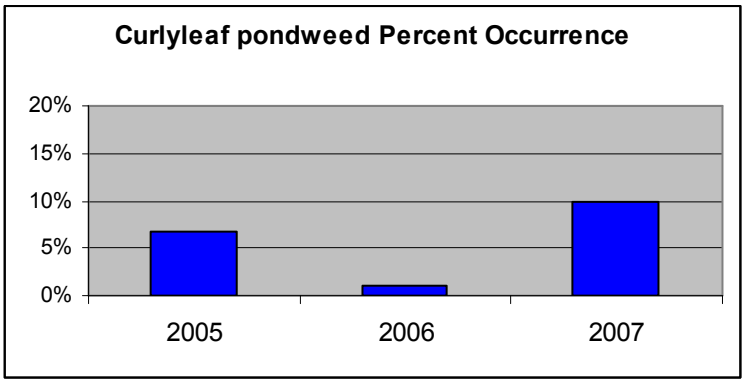

Figure 11. Crooked Lake, Curlyleaf pondweed percent occurrence in the last three summer surveys.

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Another goal of the original plan was to maintain a stable, diverse, aquatic plant community. The Tier II surveys offer a tool for quantifying changes in the submersed native plant population. Overall metrics seem to reflect little change within the plant population over the past three surveys (Figures 12 & 13).

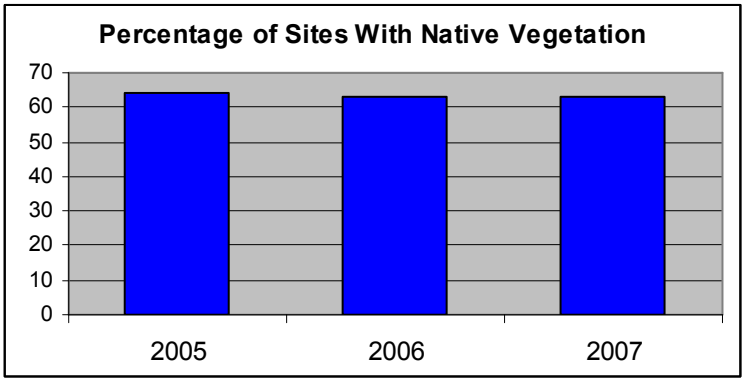

Figure 12. Crooked Lake, percentage of sample sites with native vegetation in the last three summer surveys.

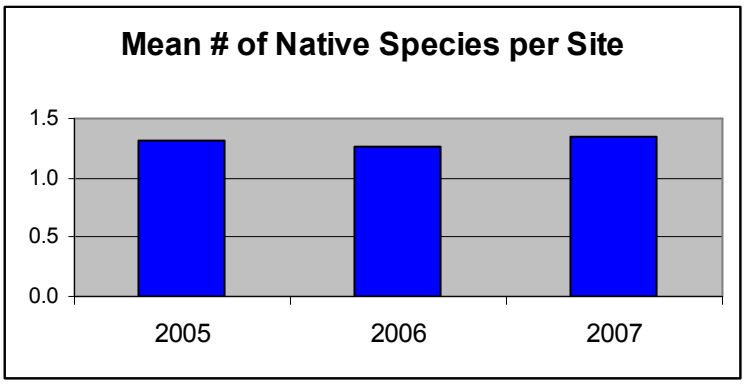

Figure 13. Crooked Lake, mean number of native species per site in the last three summer surveys

There were fewer native species collected in 2007 than in 2006. Table 2 summarizes the data from the past three surveys as it relates to percent occurrence of individual species. Small pondweed, variable milfoil, variable pondweed, brittle naiad, western elodea, water stargrass were all collected in 2006 but not in 2007. Most of these species were present at a low percentage of sites in 2006 with the exception of variable pondweed. The reduction may be due to some native impact from the fluridone treatment in third basin and recovery should be noticed by next season. Southern naiad, leafy pondweed, and flatstem pondweed were all collected in the 2007 survey but not collected in 2006. Reduction in frequency of occurrence was most evident in Eurasian watermilfoil which dropped from 60% to 16% occurrence.

Table 2. Percent occurrence of species collected in the last three Tier II surveys on Crooked Lake (2005 data provided by IDNR).

Species	% of survey sites (9/05)	% of survey sites (8/06)	% of survey sites (8/07)
Eurasian watermilfoil *(Myriophyllum spicatum)*	32.1%	60.0%	16.0%
curlyleaf pondweed *(Potamogeton crispus)*	6.7%	1.0%	10.0%
common coontail *(Ceratophyllum demersum)*	11.2%	10.0%	14.0%
Chara (Chara spp.)	13.4%	29.0%	33.0%
Slender naiad *(Najas flexillis)*	7.5%	40.0%	29.0%
sago pondweed *(Potamogeton pectinatus)*	19.4%	5.0%	10.0%
small pondweed *(Potamogeton pusillus)*	-	1.0%	-
eel grass *(Vallisneria americana)*	2.2%	1.0%	3.0%
American elodea *(Elodea canadensis)*	1.5%	1.0%	9.0%
southern naiad *(Najas guadalupensis)*	-	-	2.0%
spiny naiad (Najas marina)	0.7%	-	-
leafy pondweed *(Potamogeton foliosus)*	-	-	1.0%
flatstemmed pondweed *(Potamogeton zosteriformis)*	1.5%	-	5.0%
Richardson's pondweed *(Potamogeton richardsonii)*	3.0%	1.0%	8.0%
large leaf pondweed *(Potamogeton amplifolius)*	-	8.0%	9.0%
variable pondweed *(Potamogeton gramineus)*	23.1%	10.0%	-
variable milfoil *(Myriophyllum heterophyllum)*	-	2.0%	-
water stargrass *(Zosterella dubia)*	3.0%	3.0%	-
common bladderwort *(Utricularia vulgaris)*	2.2%	4.0%	1.0%
western elodea (*Elodea nuttali*)	-	1.0%	-
brittle naiad *(Najas minor)*	-	3.0%	-
Illinois pondweed *(Potamogeton illinoensis*	1.5%	5.0%	-

3.0 2007 VEGETATION CONTROLS

In 2007, Eurasian watermilfoil was the primary target of vegetation controls. The action plan called for a whole basin fluridone treatment in the third basin and spot treatments with 2,4-D granular herbicide in the first and second basins.

The goal of the third basin fluridone treatment was to maintain a fluridone concentration above 3ppb for 90 days. In order to monitor the concentration, five sets of FasTests were scheduled to be taken over the 90 day period. These tests allow the applicator to make precise and timely bumps to the fluridone levels. Tests were taken from three different locations within the third basin (Figure 14).

Figure 14. Crooked Lake, 2007 FasTEST sample locations.

Aquatic Management Inc. was the winning bidder of the application contract. Aquatic Management applied an initial 8 ppb dose of fluridone on May 14 (brand name of fluridone product was Sonar AS which is a liquid formulation). An application boat fitted with submersed dropper hoses was used to spread Sonar AS evenly throughout the third basin. Initial testing was competed on May 17 in order to monitor the actual fluridone concentrations. Tests were taken from three sites and the average of the 3 tests was 6.8 ppb. A bump application was completed on May 23 with a 2.8 ppb dose of fluridone in order to keep the concentration above 3 ppb. Tests were completed on June 6 and results indicated the third basin had an average concentration of 5.4 ppb. Another test was completed on June 26 and results averaged out to be 3.1 ppb. The third and final bump treatment was completed on July 2 with a 3 ppb dose. Tests were completed on

July 18 and averaged 5.0 ppb. The final tests were completed on August 6 and averaged 3.5 ppb (Figure 15). The goal of maintaining a concentration above 3 ppb for 90 days had been achieved and the milfoil was significantly reduced.

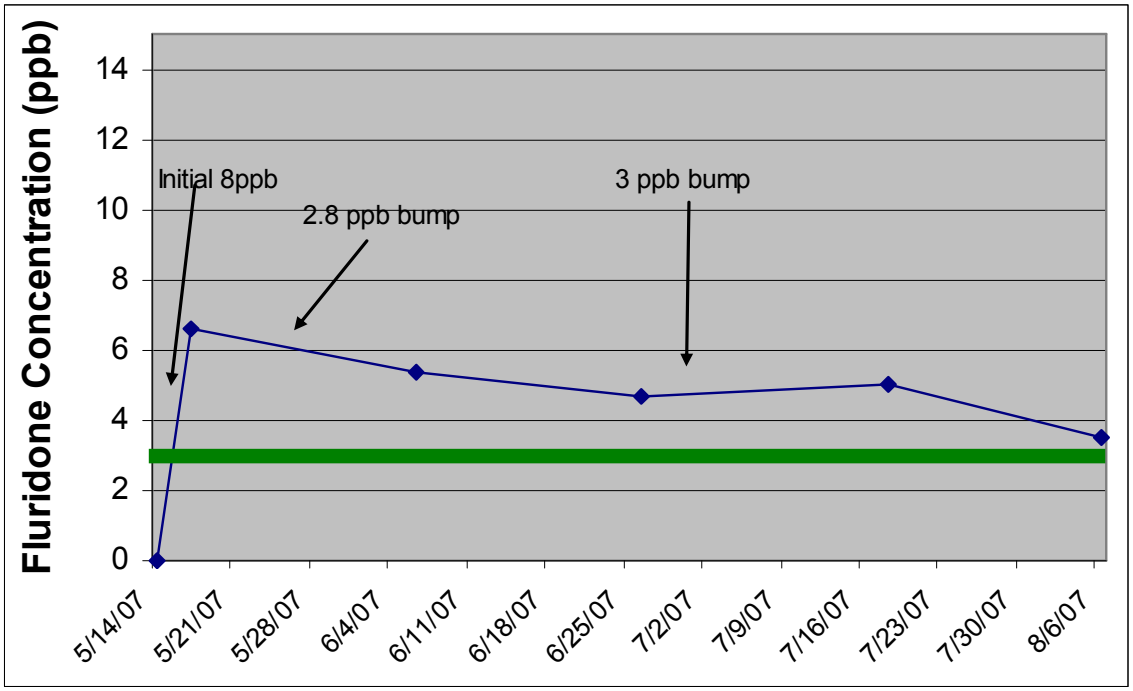

Figure 15. Crooked Lake, 2007 average of third basin fluridone concentrations.

In addition to the third basin fluridone treatment, on May 22, Aquatic Management treated 62 acres of milfoil in the first and second basins (Figure 16). Treatment areas were mapped out during the previously discussed invasive mapping survey. Aquatic Control supplied Aquatic Management with the coordinates of the milfoil beds. Aquatic Management downloaded the coordinates onto their GPS devices in order to insure the product was being applied to the proper areas. Granular 2,4-D was used in this treatment (trade name Navigate). The granular material was applied with two gas powered spreaders mounted on the front of the boat. Both treatments significantly reduced milfoil abundance.

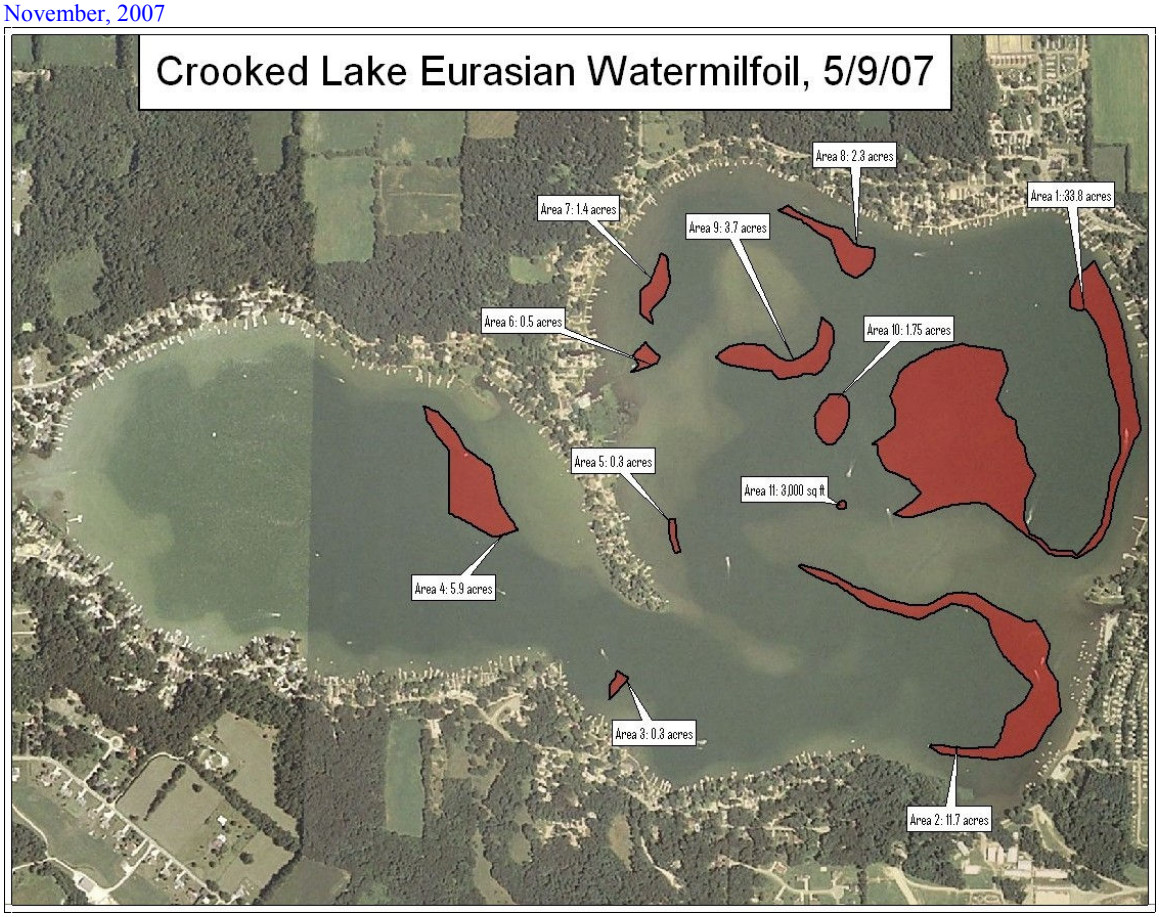

Figure 16. Crooked Lake first and second basin 2,4-D treatment areas, May 22, 2007.

4.0 PUBLIC INVOLVEMENT

A public meeting was held on September 19, 2007 at a real estate office near Crooked Lake. Approximately 14 lake users attended the meeting along with Neil and Nick Gerber of Aquatic Management. Aquatic Control presented information on plant management activities, plant sampling, invasive species, and property owner best management practices. A survey of lake users was also distributed at the meeting. Results of this survey are summarized in Table 3.

Table 3. Crooked Lake, lake user survey, September 19, 2007.

Crooked Lake User Survey 9/19/07		
Are you a lake property owner?	Yes 100%	No 0%
Are you currently a member of your lake association?	Yes 100%	No 0%
How many years have you been at the lake?	2 or Less: 7%	5 to 10: 14%
	2 to 5: 0%	Over 10: 79%
How do you use the lake (mark all that apply)	100% Swimming	50% Irrigation
	93% Boating	0% Drinking water
	43% Fishing	0% Other _____
Do you have aquatic plants at your shoreline in nuisance quantities?	Yes: 21% No: 79%	
Does aquatic vegetation interfere with your use or enjoyment of the lake?	Yes: 28% No: 72%	
Does the level of vegetation in the lake affect your property values?	Yes: 64% No: 36%	
Are you in favor of continuing efforts to control vegetation on the lake?	Yes: 100% No: 0%	
Are you aware that the LARE funds will only apply to work controlling invasive exotic species, and more work may need to be privately funded?	Yes: 100% No: 0%	
Were you satisfied with the results of the LARE funded invasive treatments this season?	Yes: 86% No: 7% (7% no response)	
Mark any of these you think are problems on your lake:		
36% Too many boats access the lake		
50% Use of jet skis on the lake		
0% Too much fishing		
0% Fish population problem		
50% Dredging needed		
14% Overuse by nonresidents		
21% Too many aquatic plants		
14% Not enough aquatic plants		
7% Poor water quality		
43% Pier/funneling problem		

Another topic discussed at the public meeting was the discovery of Hydrilla (*Hydrilla verticillata*) in Lake Manitou. Hydrilla is an invasive aquatic species that was originally discovered in Florida in the 1960's. There are many characteristics of hydrilla that make it a threat to Indiana waterways. This species can grow in lower light conditions than most native species, grows faster than most native species, and can shade out other species by forming a surface canopy. Hydrilla can be easily confused with native elodea. The best way to distinguish Hydrilla is that it typically has five leaves along each whorl along with visible serrated edges along the leaf margin (Figure 17). What makes controlling the spread of Hydrilla difficult is the fact that it can be spread by fragments. **That is why it is vitally important that lake users remove all plants and sediment from their boats when entering and leaving Crooked Lake.** More information about controlling the spread of Hydrilla can be found at www.protectyourwaters.net.

Figure 17. Illustration of Hydrilla on the left compared to native elodea on the right. Hydrilla typically contains five toothed leaves per whorl while native elodea typically has three leaves per whorl and the teeth are not visible on the leaves (Illustrations provided by Applied Biochemist).

5.0 ACTION PLAN AND BUDGET UPDATE

In 2007, the primary vegetation management action focused on the control of milfoil. A combination of spot treatments with 2,4-D in the first and second basins along with a third basin fluridone treatment was completed. LARE funded $20,000 of the treatment cost while the Association picked up the remaining expenses. The treatments were effective at significantly reducing milfoil abundance and relieving nuisance conditions in 2007. The key to the plan is providing long-term control of milfoil. In order to achieve long term control, any remaining areas of milfoil will have to be addressed. It is unlikely that milfoil will be eradicated with the 2,4-D treatments in the first and second basins, but it is likely that next season's abundance will be reduced. Milfoil was detected during the summer survey which adds to the likelihood that some will be present in 2008. Based on the summer survey and past experience it is estimated that less that 50 acres of milfoil

will be present in 2008. Figure 18 illustrates areas of concern for next season. These are areas in the first and second where milfoil was detected during the summer Tier II survey. It is unlikely that the third basin will require significant treatment since it was treated with fluridone, however, if any milfoil is detected in third basin it should be treated.

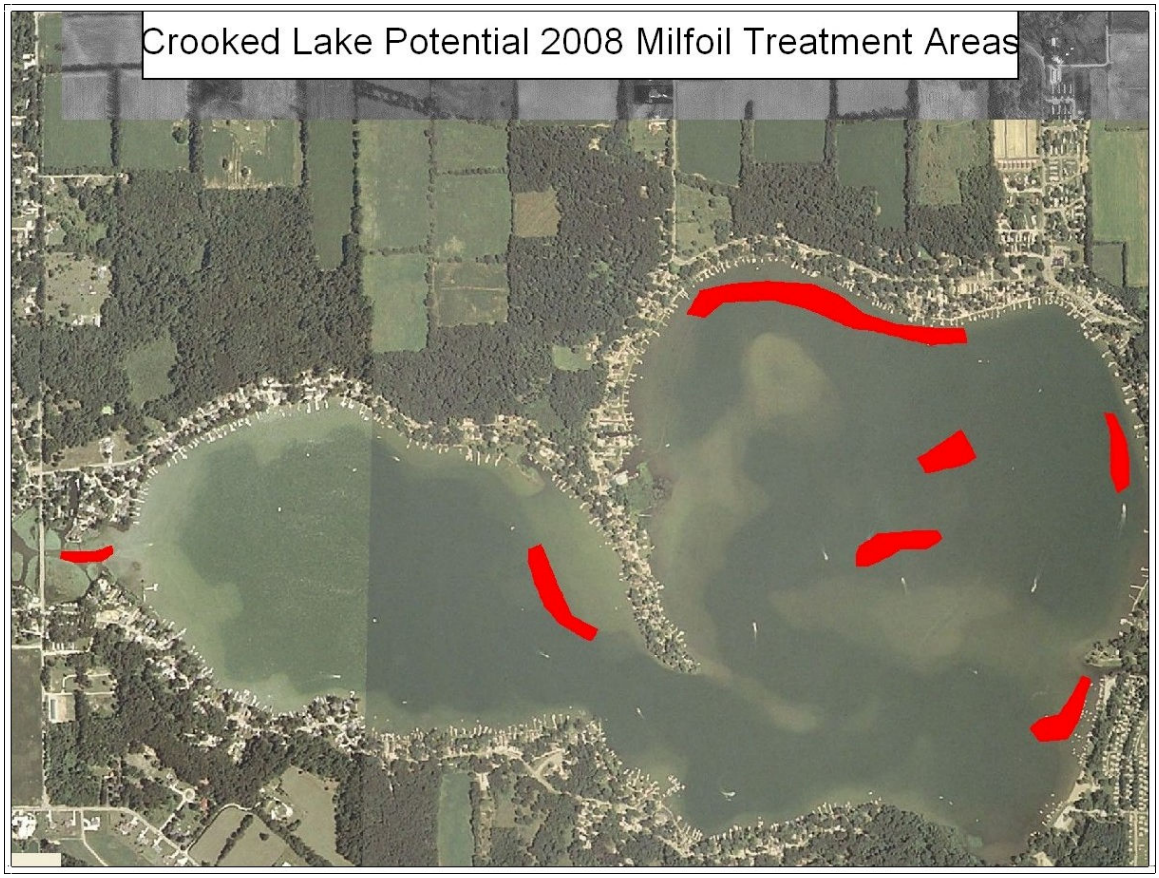

Figure 18. Crooked Lake, milfoil areas of concern for the 2008 season.

One of the more difficult but important aspects of the action plan will be detection and mapping of the milfoil areas. This should be completed in early to mid May with treatment being completed in mid to late May in order to lessen the likelihood of milfoil spread. If Secchi readings are normal, the majority of mapping can be completed by driving a boat in a tight zigzag fashion over the littoral area. When milfoil is located a GPS unit should be used to outline the plant bed. A rake should be used to check for milfoil throughout historical areas of infestation and in the areas marked in Figure 18. A follow-up Tier II survey should also be completed in the summer of 2008 in order to monitor native vegetation to check the effectiveness of the potential controls.

Curlyleaf pondweed will likely return at nuisance levels in 2008, especially in the third basin. The whole basin fluridone treatment may have reduced the amount of turions produced by curlyleaf in 2007, but since curlyleaf turions can survive for several seasons before sprouting there will likely be nuisance levels of curlyleaf in the spring of 2008. Curlyleaf was also present at higher levels in the first basin when comparing the 2007 data to the 2005 and 2006 data. Turion formation typically occurs at peak biomass

(Woolf & Madsen, 2003), so treatment of curlyleaf should occur well before this time. In northern Indiana peak biomass usually occurs in late May or early June. Based on past experience, personal communication with product manufacturers and researchers, along with a journal review, we believe that treatment should occur once the water reaches a consistent 50 degrees Fahrenheit. In addition to reduced turion production, early applications may improve the selective potential of the herbicide because fewer native plant species are actively growing in cooler water temperatures and therefore are less susceptible to herbicide treatment (Poovey et. al. 2002). In addition, algae blooms have been associated with senescence in response to the release of nutrients following decline of large stands of curlyleaf pondweed (Hill 1979, Hill and Webster 1982 cited in Netherland et. al., 2000). Early season control of curlyleaf should help reduce the amount of nutrients taken from the substrate and made available to microscopic algae in the water column.

Curlyleaf is very susceptible to low doses of endothal (trade name Aquathol K). Diquat also has good activity on curlyleaf, but endothal appears to be more effective in cool water (Poovey et. al. 2002). Applicators have varied treatment rates for control of curlyleaf from a low of 0.5 ppm to a high of 1.5 ppm. We typically recommend a rate of 1.0 ppm for early season control. This rate is based on past experience, literature review, ongoing Army Corp of Engineers research, labeled rates, and the manufacturer's recommendation.

Up to 155 acres of curlyleaf pondweed may be present in Crooked Lake next season (Figure 19). This estimate is based upon the findings from the 2007 invasive plant mapping survey. Curlyleaf pondweed will likely be most abundant in the third basin (133 acres). This basin is relatively shallow with an average depth of approximately 4.0 feet, so that would reduce the cost of treatment compared to treating lakes with much deeper areas (in order to achieve 1.0 ppm in 133 acres of the third basin you would need 2.4 gallons of Aquathol K per acre). This treatment should be completed for at least three consecutive seasons in order to exhaust turion supplies. The author understands the budget limitations of the Association and LARE to fund such a treatment, however, if an invasive species such as curlyleaf is to be controlled potential actions need to be addressed. Control and monitoring of the Eurasian watermilfoil should take precedent over the potential curlyleaf controls because milfoil has a greater chance of interfering with summer boating activities and large initial milfoil control investments were already made in 2007.

If a large-scale curlyleaf treatment is funded next season it will be important to have good baseline curlyleaf abundance data. This should at least include a pre-treatment Tier II survey. In addition to the Tier II sampling, curlyleaf turion sampling would help address the reduction in the turion population, which is the ultimate goal of the treatment program (sampling protocol will be included in final draft, waiting on ACOE to get a protocol to me).

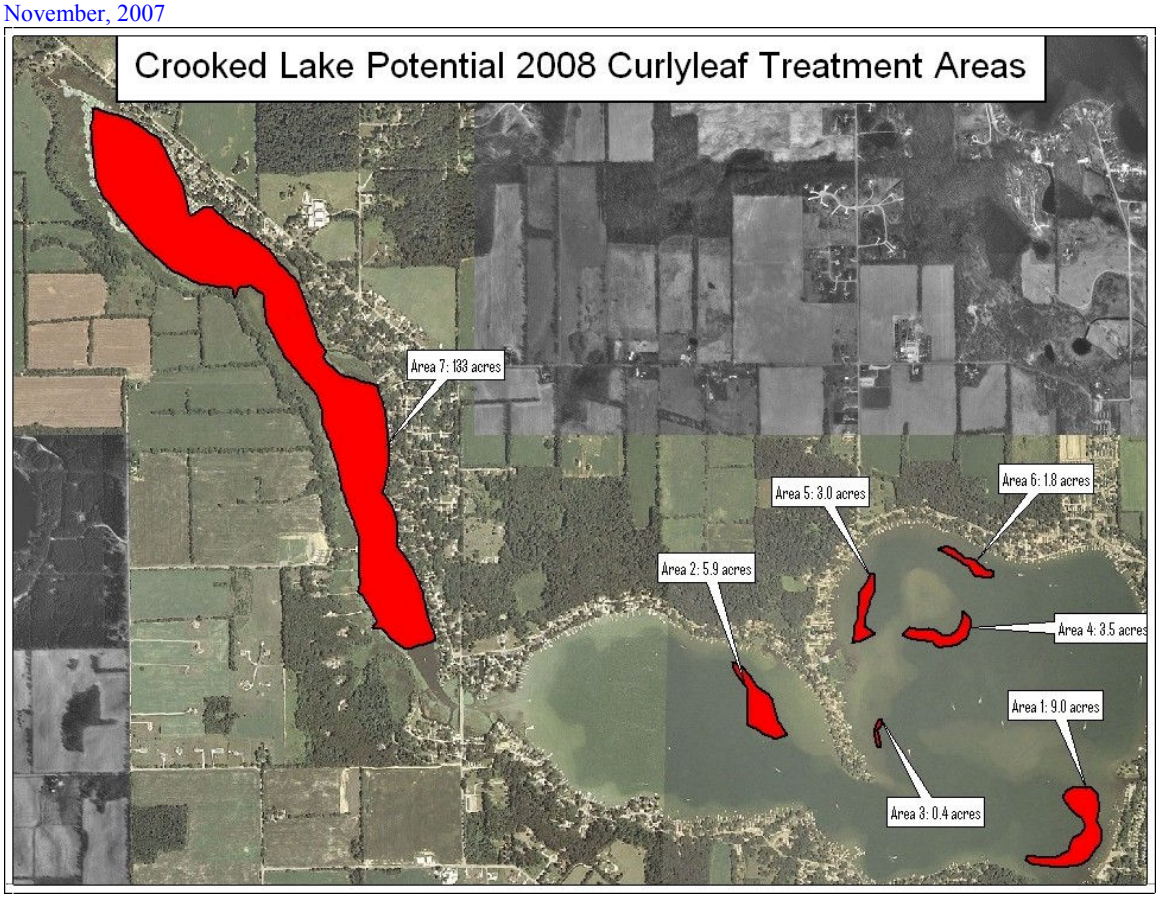

Figure 19. Crooked Lake, 2008 potential curlyleaf pondweed treatment areas.

There are high use areas of the lake that may require some control of native vegetation. These areas include, docks, boat ramps, and beaches. Treatment of native vegetation should be limited to these high-use areas and only completed where native vegetation is actually impacting lake use. Registered contact herbicides are effective for short term relief of nuisance conditions and ideally a professional should complete the treatment. A professional applicator will have to apply for permits in order to complete such a treatment. However, homeowner's can legally control vegetation in a 625 square-foot areas of their shoreline without a permit. Any vegetation treated with herbicides or manually removed that extends beyond the 625 square foot area will require an IDNR permit.

Efforts to educate residents on the benefits of native vegetation should be continued. This may include annual meetings, newsletters, ILMS conferences or workshops and website postings. Educating residents on the value of native vegetation and proper shoreline maintenance may help enhance the Crooked Lake ecosystem. In addition, educating residents on the need to properly clean boats and trailers may help reduce the movement of invasive species into or out of Crooked Lake.

It is recommended that the Conservancy request $65,250 from the LARE program for treatment and the plan update. A total of $17,500 would be for treatment of approximately 50 acres of milfoil, $38,750 would be used for treatment of

approximately 154 acres of curlyleaf pondweed and $10,000 would go towards plant sampling and plan updates (Table 4).

Table 4. Crooked Lake, four year budget estimate.

	2008	2009	2010	2011
2,4-D Treatment for control of Eurasian watermilfoil (Eurasian watermilfoil only)	$17,500	$15,000	$12,500	$10,000
Early season Endothal treatment for control of curlyleaf pondweed	$38,750	$38,750	$38,750	-
Vegetation Sampling & Plan Update	$5,000	$5,000	$5,000	$5,000
Curlyleaf turion sampling and early spring Tier II Survey	$5,000	$5,000	$5,000	
Total w/curlyleaf:	**$65,250**	**$63,750**	**$61,250**	**$15,000**
Total w/out curlyleaf	**$22,500**	**$20,000**	**$17,500**	**$15,000**

6.0 References Cited

Netherland, M.D., Skogerboe, J.D., Owens, C.S., & Madsen, J.D. 2000. Influence of Water Temperature on the Efficacy of Diquat and Endothall versus Curlyleaf Pondweed. Journal of Aquatic Plant Management 38: 25-32.

Poovey, A.G., Skogerboe, J.G., & Owens, C.S. 2002. Spring Treatments of Diquat and Endothall for Curlyleaf Pondweed Control. Journal of Aquatic Plant Management 40: 63-67.

Woolf, T.E. & Madsen, J.D. 2003. Seasonal Biomass and Carbohydrate Allocation Patterns in Southern Minnesota Curlyleaf Pondweed Population. Journal of Aquatic Plant Management 41:113-118

7.0 Appendix Update

7.1 2007 Sampling Data-Tier II Survey

Lake	Date	Latitude	Longitude	Design	Site	Depth	RAKE	Eurasian watermilfoil (*Myriophyllum spicatum*)	curlyleaf pondweed (*Potamogeton crispus*)	common coontail (*Ceratophyllum demersum*)	Chara (*Chara* spp.)	Slender naiad (*Najas flexilis*)	sago pondweed (*Potamogeton pectinatus*)	eel grass (*Vallisneria americana*)	American elodea (*Elodea canadensis*)	southern naiad (*Najas guadalupensis*)	flatstemmed pondweed (*Potamogeton zosteriformis*)	Richardson's pondweed (*Potamogeton richardsonii*)	large leaf pondweed (*Potamogeton amplifolius*)	common bladderwort (*Utricularia vulgaris*)
Crooked Lake	8/14/07	41.682269	-85.071143		1	8.0	5	1				5							5	
Crooked Lake	8/14/07	41.669485	-85.037534		2	16.0	0													
Crooked Lake	8/14/07	41.670536	-85.039176		3	6.0	3				1	3								
Crooked Lake	8/14/07	41.670979	-85.041236		4	6.0	0													
Crooked Lake	8/14/07	41.671969	-85.042999		5	20.0	0													
Crooked Lake	8/14/07	41.673695	-85.041262		6	9.0	1	1				1						1		
Crooked Lake	8/14/07	41.673751	-85.039895		7	10.0	1			1		1								
Crooked Lake	8/14/07	41.674494	-85.038336		8	19.0	1			1										
Crooked Lake	8/14/07	41.672039	-85.036361		9	17.0	0													
Crooked Lake	8/14/07	41.673494	-85.034848		10	13.0	1			1										
Crooked Lake	8/14/07	41.675094	-85.034485		11	11.0	3	1		3		1								
Crooked Lake	8/14/07	41.676772	-85.034856		12	16.0	3									3				
Crooked Lake	8/14/07	41.678749	-85.036289		13	18.0	1					1						1		
Crooked Lake	8/14/07	41.678601	-85.037997		14	6.0	0													
Crooked Lake	8/14/07	41.678421	-85.040259		15	9.0	5	1		1		1	3		1					
Crooked Lake	8/14/07	41.678798	-85.042654		16	7.0	3	3			1	1								
Crooked Lake	8/14/07	41.67936	-85.044353		17	20.0	0													
Crooked Lake	8/14/07	41.679155	-85.047047		18	7.0	5	3			1	1		1						
Crooked Lake	8/14/07	41.677716	-85.047645		19	4.0	3					3						1		
Crooked Lake	8/14/07	41.676285	-85.048436		20	2.0	1					1								
Crooked Lake	8/14/07	41.675882	-85.046444		21	6.0	5				1	3						3		
Crooked Lake	8/14/07	41.676665	-85.044432		22	6.0	1		1			1								
Crooked Lake	8/14/07	41.677194	-85.042857		23	20.0	1					1			1	1				
Crooked Lake	8/14/07	41.674842	-85.04541		24	6.0	5				3	5	5							
Crooked Lake	8/14/07	41.673389	-85.046658		25	8.0	3				1	3		1	1					
Crooked Lake	8/14/07	41.671897	-85.046962		26	12.0	0													
Crooked Lake	8/14/07	41.670583	-85.045529		27	6.0	3		3		1									
Crooked Lake	8/14/07	41.669376	-85.043287		28	10.0	0													
Crooked Lake	8/14/07	41.67071	-85.048019		29	6.0	5					5								
Crooked Lake	8/14/07	41.671561	-85.05035		30	7.0	1						1							
Crooked Lake	8/14/07	41.672466	-85.051787		31	6.0	3	3	3											
Crooked Lake	8/14/07	41.674072	-85.052495		32	7.0	5		5		1		1							
Crooked Lake	8/14/07	41.675063	-85.053924		33	7.0	0													
Crooked Lake	8/14/07	41.675263	-85.056273		34	19.0	0													
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Crooked Lake	8/14/07	41.678025	-85.070319		44	6.0	3												3	
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Crooked Lake	8/14/07	41.685006	-85.073278		48	5.0	1	1			1									
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Crooked Lake	8/14/07	41.692487	-85.08118		54	4.0	5				5								1	
Crooked Lake	8/14/07	41.692969	-85.082579		55	6.0	1				1									
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Crooked Lake	8/14/07	41.66832	-85.041936		87	7.0	5				5	5							1	
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Crooked Lake	8/14/07	41.667516	-85.037112		91	4.0	5		1	5					1				3	
Crooked Lake	8/14/07	41.668589	-85.036618		92	5.0	5					3	1						5	
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Crooked Lake	8/14/07	41.675647	-85.039957		97	10.0	1	1					1							
Crooked Lake	8/14/07	41.675976	-85.039335		98	11.0	1	1		1										
Crooked Lake	8/14/07	41.677536	-85.036195		99	12.0	1			1		1								

7.2 2007 Vegetation Control Permit Application

			Return to: Page 1 of 4
	APPLICATION FOR AQUATIC VEGETATION CONTROL PERMIT	**FOR OFFICE USE ONLY**	DEPARTMENT OF NATURAL RESOURCES
	State Form 26727 (R / 11-03)	License No.	Division of Fish and Wildlife
	Approved State Board of Accounts 1987		Commercial License Clerk
	☐ Whole Lake ☒ Multiple Treatment Areas	Date Issued	402 West Washington Street, Room W273
	Check type of permit		Indianapolis, IN 46204
	INSTRUCTIONS: Please print or type information	Lake County	FEE: $5.00

Applicant's Name	Lake Assoc. Name	
Crooked Lake Association	Crooked Lake Association	
Rural Route or Street		Phone Number
801 West Coliseum Blvd.		260-482-7665
City and State		ZIP Code
Fort Wayne, IN		46808
Certified Applicator (if applicable)	Company or Inc. Name	Certification Number
Rural Route or Street		Phone Number
City and State		ZIP Code

Lake (One application per lake)	Nearest Town	County
Crooked Lake	Angola	Stueben
Does water flow into a water supply	☐ Yes	☒ No

Please complete one section for *EACH* treatment area. Attach lake map showing treatment area and denote location of any water supply intake.

Treatment Area #	1	LAT/LONG or UTM's	All three basins. Areas TBD following spring survey		
Total acres to be controlled	<75	Proposed shoreline treatment length (ft)		Perpendicular distance from shoreline (ft)	
Maximum Depth of Treatment (ft)	12	Expected date(s) of treatment(s)	mid to late May		
Treatment method:	☒ Chemical	☐ Physical	☐ Biological Control	☐ Mechanical	

Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control. Eurasian watermilfoil spot treated with 2,4-D herbicide following mapping survey

Plant survey method: ☒ Rake ☐ Visual ☐ Other (specify) Data collected during 2007 T-2 survey

Aquatic Plant Name	Check if Target Species	Relative Abundance % of Community
Eurasian Watermilfoil	x	15
Curlyleaf pondweed		10
Chara		25
Coontail		10
eel grass		5
Largeleaf pondweed		5
sago pondweed		10
Common Bladderwort		1
Slender naiad		15
Richardsons pondweed		1
leafy pondweed		1
variable watermilfoil		1
flatstem pondweed		1

Page 2 of 4

Treatment Area #	2	LAT/LONG or UTM's	Areas TBD following spring survey-predicted areas on map
Total acres to be controlled	155	Proposed shoreline treatment length (ft)	Perpendicular distance from shoreline (ft)
Maximum Depth of Treatment (ft)	12	Expected date(s) of treatment(s)	April or when water temp is consistent 50 degrees

Treatment method: [x] Chemical [ ] Physical [ ] Biological Control [ ] Mechanical

Based on treatment method, describe chemical used, method of physical or mechanical control and disposal area, or the species and stocking rate for biological control. Early season aquathol K at 1 ppm when water reaches consistent 50 degrees

Plant survey method: [x] Rake [ ] Visual [ ] Other (specify) Data collected in summer T2 survey

Aquatic Plant Name	Check if Target Species	Relative Abundance % of Community
Eurasian Watermilfoil		15
Curlyleaf pondweed	x	10
Chara		25
Coontail		10
eel grass		5
Largeleaf pondweed		5
sago pondweed		10
Common Bladderwort		1
Slender naiad		15
Richardsons pondweed		1
leafy pondweed		1
variable watermilfoil		1
flatstem pondweed		1

INSTRUCTIONS: Whoever treats the lake fills in "Applicant's Signature" unless they are a professional. If they are a professional company who specializes in lake treatment, they should sign on the "Certified Applicant" line.

Applicant Signature	Date
Certified Applicant's Signature	Date

FOR OFFICE ONLY

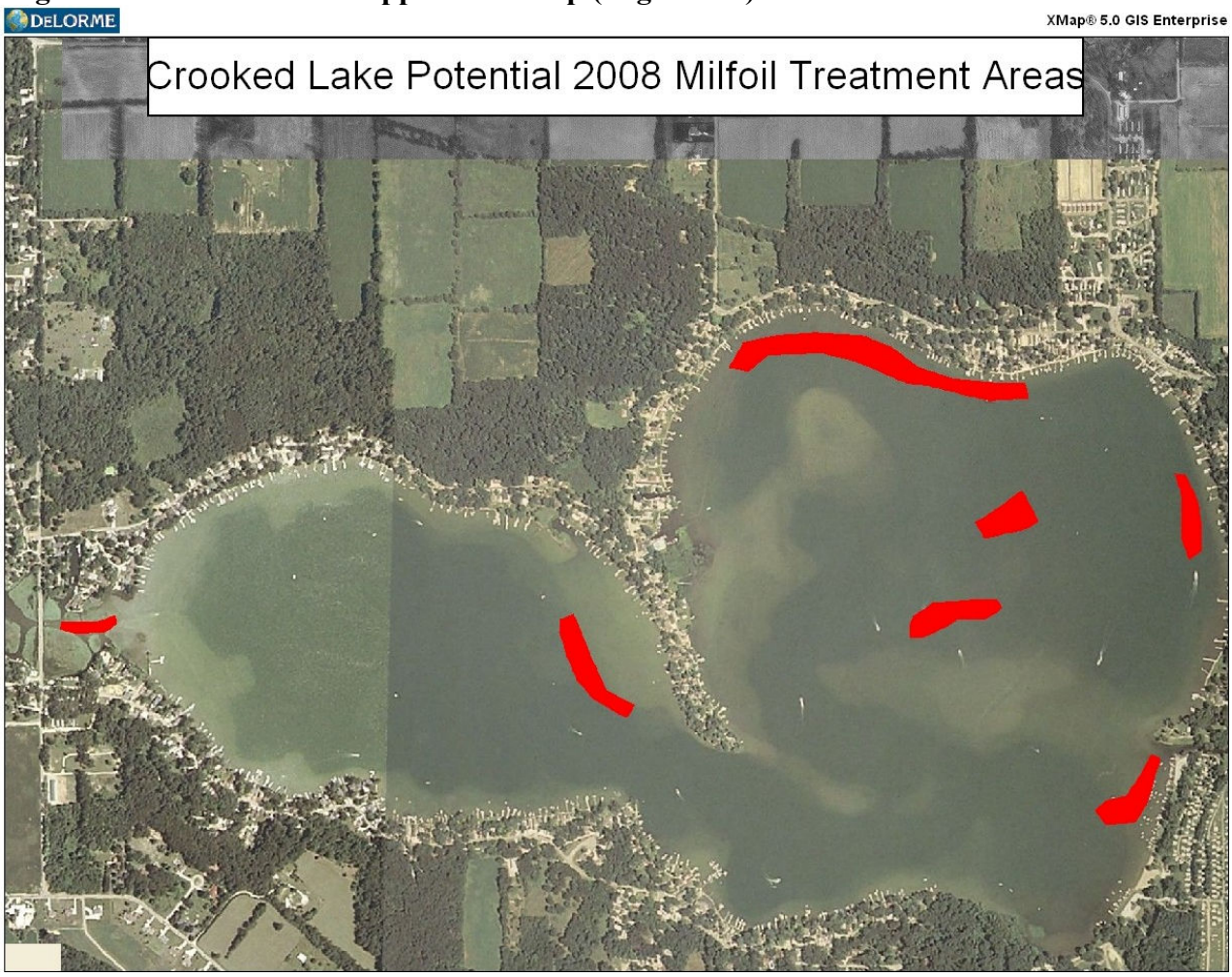
[ ] Approved [ ] Disapproved	Fisheries Staff Specialist
[ ] Approved [ ] Disapproved	Environmental Staff Specialist

Mail check or money order in the amount of $5.00 to:

DEPARTMENT OF NATURAL RESOURCES
DIVISION OF FISH AND WILDLIFE
COMMERCIAL LICENSE CLERK
402 WEST WASHINGTON STREET ROOM W273
INDIANAPOLIS, IN 46204

AQUATIC CONTROL

Vegetation Control Permit Application Map (Page 3 of 4)



Vegetation Control Permit Additions (Page 4 of 4):